REMARKS

The applicants appreciate the Examiner's thorough examination of the Application and request reexamination and reconsideration of the Application in view of the following remarks.

Claims 1-10, 14-28 and 32-39 stand rejected under 35 USC §102(b) as allegedly being anticipated by U.S. Patent No. 5,735,332 to Ritland et al. To advance prosecution, Applicants herein amend independent claims 1, 15, 19, 23, 27 and 28 to emphasize that the recited metal matrix is infused under pressure into the preform and that the metal matrix material is selected from aluminum, an aluminum alloy, magnesium or a magnesium alloy. Claims 10, 29 and 39 have been cancelled since features of these claims have been incorporated into the independent claims. Applicants have added new claims 41-44 to emphasize that the recited metal matrix may be infused under pressure into the preform by, for example, pressure casting or squeeze casting.

The subject invention results from the realization that a more durable metal matrix composite with a higher tensile strength and which sufficiently retains its tensile strength and stiffness at elevated temperatures is effected by the use of a partially sintered reinforcement preform tailored to have a specified pore size, porosity, and flexure strength, by choosing substantially pure ceramic powders, and by carefully selecting the metal matrix material, which can be aluminum, magnesium, or an alloy of these, to be infused into the preform depending on the choice of the ceramic powders. Ceramic powders are partially sintered resulting in an isotropic reinforcement preform. The preform is infused with a metal matrix material under pressure by pressure casting, squeeze casting, or similar techniques, which results in an isotropic metal matrix

composite with high strength, high stiffness, temperature resistance, a low coefficient of thermal expansion, and good wear resistance properties.

Ritland et al. shows a method for making a ceramic metal composite that includes pre-sintering a green body of alumina powder for three minutes at 1500° C and then placing the pre-sintered body into a sintering furnace that sinters the alumina body for about 80 minutes at a temperature of 1600° C. See Ritland et al. at column 10, lines 12-29. Next, metal is infiltrated into the preform preferably in the presence of a vacuum atmosphere. Ritland et al states that "[the] evacuation of air from the ceramic void space reduces the likelihood that air pockets will form in the metal infrastructure." See Ritland et al. at column 8, lines 58-63.

Ritland et al. does not teach, disclose or suggest, however, a metal matrix composite that includes a metal matrix infused <u>under pressure</u> into a preform that includes partially sintered ceramic particles. Also, as described below and in the attached Affidavit, Ritland et al. incorrectly states that certain infiltrant metals including aluminum and magnesium could be fabricated with a ceramic matrix material via pressureless infiltration to produce a metal matrix composite (MMC).

In contrast to Ritland et al., the metal matrix composite as claimed by Applicants uses a metal matrix infused <u>under pressure</u>, such as by pressure casting, squeeze casting, or other similar techniques, into a preform that includes partially sintered ceramic particles. The metal matrix material is selected from aluminum, magnesium or an alloy of these. As noted above, using pressure to infuse the preform with one of these metal matrix materials results in an isotropic metal matrix composite with high strength, high stiffness, temperature resistance, a low coefficient of thermal expansion, and good wear resistance properties.

Not only does Ritland et al. not teach, disclose or suggest the subject invention as claimed by Applicants, it actually teaches away from the subject invention. In the background of the invention, Ritland et al. clearly describes the disadvantages of squeeze casting or applying pressure to the molten metal. Specifically, Ritland et al. teaches that:

> The major disadvantage of [squeeze casting and applying pressure to the molten metal], however, is that it is difficult to achieve near complete infiltration of the void space within the preforms without use of substantial pressures. In addition, when ceramic preform materials contain a high volume porosity, use of pressure in squeeze casting techniques can crumble the delicate ceramic structure.

Ritland et al. at column 2, lines 1-7. Moreover, as noted above, Ritland et al. teaches metal is preferably infiltrated into the preform <u>in the presence of a vacuum atmosphere</u> since "[the] evacuation of air from the ceramic void space reduces the likelihood that air pockets will form in the metal infrastructure." See Ritland et al. at column 8, lines 58-63. Thus, to those skilled in the art, Ritland et al. clearly teaches away from using a metal matrix infused <u>under pressure</u> into a preform that includes partially sintered ceramic particles, as claimed by Applicants.

Moreover, as discussed in the attached Affidavit executed by one of the inventors of the subject application, Ritland et al. incorrectly states that certain infiltrant metals including aluminum and magnesium could be fabricated with a ceramic matrix material via pressureless infiltration to produce a metal matrix composite (MMC). See Ritland et al. at column 4, lines 59-66. While it could be potentially possible to produce via pressureless infiltration a copper/aluminum oxide MMC (the primary materials of Ritland et al.), it is not possible to produce high strength aluminum/aluminum oxide MMCs in this manner based upon the experimental data discussed in the Affidavit. Aluminum/aluminum oxide MMCs

produced via pressureless infiltration without special procedures to enhance wetting are documented to have poor infiltration and projected to have low tensile strength well below 80 ksi, which is in contrast to the subject invention as claimed by Applicants.

Claim 1 of the subject application recites a "metal matrix composite comprising an isotropic reinforcement preform made by partially sintering ceramic particles, and a metal matrix infused <u>under pressure</u> into the preform yielding an isotropic metal matrix composite having an ultimate tensile strength of at least 80 ksi in all directions, <u>the metal matrix material selected from the group consisting of aluminum, an aluminum alloy, magnesium or a magnesium alloy</u>". (Emphasis added.) As discussed above, Ritland et al. does not teach, disclose or suggest a metal matrix composite that includes a metal matrix infused <u>under pressure</u> into the preform, <u>or a metal matrix that includes a material selected from the group consisting of aluminum, an aluminum alloy, magnesium or a magnesium alloy to produce a metal matrix composite having an ultimate tensile strength of a least 80 ksi in all directions</u>, as claimed by Applicants. Independent claims 15, 19, 23, 27 and 28 each includes similar features that distinguish over Ritland et al.

Accordingly, claims 1-10, 14-28 and 32-39 are patentable over Ritland et al. Applicants respectfully request that the Examiner withdraw the rejection of these claims under 35 USC §102(b).

Claims 11-13, 29-31 and 40 stand rejected under 35 USC §103(a) as allegedly being unpatentable over Ritland et al. Since each of these claims depends from one of the independent claims 1, 15, 19, 23, 27 or 28, they are patentable for at least the reasons stated above and are further patentable because they include one or more additional features.

Accordingly, claims 11-13, 29-31 and 40 are patentable over Ritland et al. Applicants respectfully request that the Examiner withdraw the rejection of these claims under 35 USC §103(a).

If for any reason this Response is found to be incomplete, or if at any time it appears that a telephone conference with counsel would help advance prosecution, please telephone the undersigned or his associates collect in Waltham, Massachusetts, at (781) 890-5678.

Respectfully submitted,

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IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Applicants:	Rozenoyer et al.	Confirm. No.:	4457
Serial No.:	10/715,943	Group:	1742
Filed:	November 18, 2003	Examiner:	Mai, Ngoclan Thi
For:	METAL MATRIX COMPOSITE	Dkt No.:	FM-219J

AFFIDAVIT

I, Uday Kashalikar, hereby say:

That I am one of the inventors for the above-identified patent application; and

That the above-identified patent application differs from the prior art in the ways discussed below.

Ritland et al. incorrectly states that several infiltrant metals, including aluminum and magnesium, could be fabricated with a ceramic matrix material via pressureless infiltration to produce a metal matrix composite (MMC). See Ritland et al. at column 4, lines 59-66. While it could be potentially possible to produce via pressureless infiltration a copper/aluminum oxide MMC (the primary materials of Ritland et al.), it is not possible to produce high strength aluminum/aluminum oxide MMCs in this manner based upon the experimental data discussed below. Aluminum/aluminum oxide MMCs produced via pressureless infiltration without special procedures to enhance wetting are documented to have poor infiltration and projected to have low tensile strength well below 80 ksi, which is in contrast to the subject invention as claimed by Applicants.

Numerous published studies and U.S. and European patents [1, 2, 3, 4, 5] have documented the poor wetting of aluminum oxide preforms (reinforcement) by molten

aluminum, hence complicating fabrication of aluminum/aluminum oxide MMCs. The poor wettability of alumina (aluminum oxide) preforms by aluminum melt leads to incomplete infiltration of preforms and can also cause agglomeration of aluminum oxide particulates, both of which compromise mechanical properties of the resulting MMC material.

Another mechanism to promote infiltration of preforms in non-wetting systems is to produce a reaction between the preform material and the melt. This is not a preferred approach because the reaction can deteriorate the strength of the preform and the resulting composite. The non-wettability problem is exacerbated when micro-porous pre-sintered aluminum oxide preforms are used for MMC fabrication, because of the torturous and microfine infiltration pathway in the preform material.

The non-wetting nature of the alumina preform by aluminum melt does not support pressureless (capillary based) infiltration of the pathways in the preform. In fact, reference [6] states that the non-wetting nature of the alumina makes it practically impossible to infiltrate even much looser particulate- or whisker-based alumina preforms by pressureless (capillary based) infiltration.

To enhance wetting of aluminum oxide by aluminum melt, the two following approaches have been extensively studied [4, 5, 7], but these approaches have not produced MMC materials having a tensile strength greater than 80 ksi:

1. *Increase processing temperature and/or to have controlled atmosphere to activate wetting and preform/melt reactivity.* The temperature needs to be increased to more than 1100-1300°C in order to cause wetting between alumina and molten

aluminum [3, 4]. At this high processing temperature, the alumina preform undergoes microstructural changes, viz., sintering and grain growth [8, 9], both of which compromise mechanical properties of the resulting MMC material. The highest achieved tensile strength of pressureless infiltrated isotropic alumina/aluminum MMCs produced via this approach is about 50 ksi [10].

2. *Alloying of the aluminum melt with active elements (Mg, Ti, Zr, Hf, etc.) to promote chemical reactions and wetting between aluminum oxide reinforcement an aluminum alloy melt.* This approach leads to several negative consequences: reinforcement structure and properties deterioration, matrix alloy composition alterations and subsequently MMCs mechanical property degradation [6, 11], which results in an MMC having a tensile strength less than 80 ksi.

Thus, as discussed above, aluminum/aluminum oxide MMCs produced via pressureless infiltration without special procedures to enhance wetting are documented to have poor infiltration and projected to have low tensile strength well below 80 ksi.

<u>Selected References</u> (provided upon request)

1. Cappleman, G.R. et al., Journal of Materials Science (1985), No. 20, 2159.
2. Mortensen, A. & Cornie, J.A., Metallurgical and Materials Transactions A (1987), Vol. 18A, 1160-63.
3. Javernick, D.A. et al., Metallurgical and Materials Transactions A (1998), Vol. 29A, 327.
4. Sobczak, N. et al., Metallurgical and Materials Transactions A (2004), Vol. 35A, 911
5. Burke, J.T., U.S. Patent No. 5,150,747, Issued September 29, 1992.
6. McCullough, C. et al. European Patent No. EP 0833952 B1, Feb. 28, 2001.
7. Deve, H.E. et al., Journal of Metals (July 1995), 33.

8. Engineered Materials Handbook, Vol. 4, Ceramics and Glasses, ASM International, 1991, 752-753.
9. Wilson, D.M., New High Temperature Oxide Fibers, 3M Co., St. Paul, MN, www.3m.com/market/industrial/ceramics/pdfs/New_High_Temp_Oxide_Fibers.pdf.
10. Aghajanian, M.K., Properties and Micrstructure of Lanxide® A12O3-Al Ceramic Composite Materials, Journal of Materials Science, 24 1989, 658-670.
11. Fukunaga, H. et al., U.S. Patent No. 6,524,061 B1, Issued Feb. 18, 2003.

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

Further deponent saith not.

Uday Kashalikar

4-14-05
Date